

COSMOS-243 MICROWAVE MEASUREMENTS
OVER GREENLAND ICE

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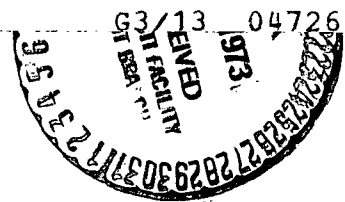
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Measurements of radio brightness temperatures of ice regions were made at wavelengths $\lambda_1 = 8.5$ cm, $\lambda_2 = 3.4$ cm, $\lambda_3 = 1.35$ cm and $\lambda_4 = 0.8$ cm by the Cosmos-243 satellite. The antennas of all receivers were directed vertically downward, and no scanning was used [1]. The basic results of the study of characteristics of thermal radiation of the Arctic are presented in [2]. /3

In the northern hemisphere, Greenland is a region which is similar to the Antarctic in its temperature mode and ice cover peculiarities. Figure 1 shows the geographic contours of Greenland. The characteristic radio brightness profile of Greenland is shown in Figure 2. Analysis of the profiles produced and their correlation to the corresponding geographic region have shown that the western shore of Greenland, right up to 71°N (highest latitude reached by the Cosmos-243 satellite), is free of floating ice. /4

When the satellite crossed the western boundary of Greenland, the type of the signal correlated to the nature of the topographic peculiarities of the shore. For example, sector "1" on the radio brightness profile corresponds to crossing of the Svartenkhuk Peninsula, while sector "2", with reduced radio brightness, corresponds to Karratsfjord. Masses of floating ice are noted along the eastern shoreline. Between 67° and 71°N , the boundary of the floating ice moves to 50-150 km from the shoreline. On the radio brightness profile, the floating ice corresponds to sector "4" with the maximum radio brightness. The floating ice of Greenland, as in Antarctica, has a higher brightness temperature than the surface of the continent, which is explained by the temperature mode of the mass of continental ice. /5

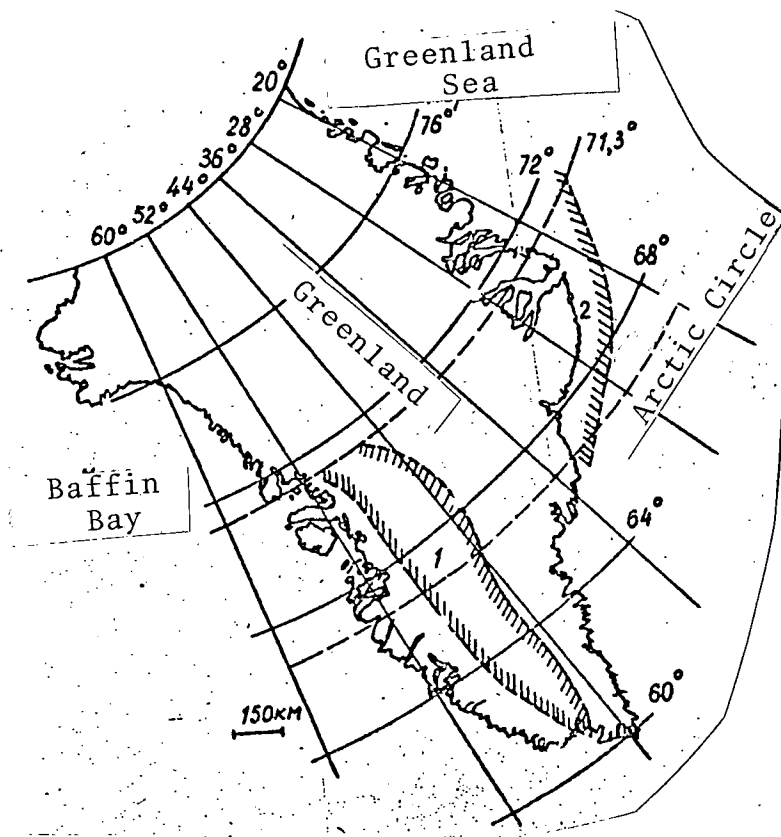


Figure 1. Contour of Greenland: 1, Region with Low Radio Brightness; 2, Floating Ice

Processing of the results of radiometric measurements has shown that the radio brightness temperature of the continent of Greenland, like Antarctica, differs significantly over the spectrum. This difference, along with the possible spectral dependence of radiating capacity of the snow-firn mass, is determined by the deep penetration of radio waves into the continental ice and the peculiarities of temperature distribution through the surface layer. As we know, the brightness temperature at wavelength λ is determined by the thermodynamic temperature at the depth of radiating layer l_e , determined by the depth of penetration of the electromagnetic wave. The depth of penetration of the electromagnetic wave is determined by the value of losses $\tan \delta$ and the dielectric permeability of the material of the surface layer. With values of parameters $\tan \delta$ and ϵ

/6

characteristic for the ice cover of Greenland, presented in [3], we find that for the continental ice the depth of the radiating layer may be as great as 100λ [4]. Consequently, the value of l_e falls within limits of 0.5-1 m at the shortest wavelength λ_4 , up to 5.0-10.0 m at the longest wavelength λ_1 . Thus, the

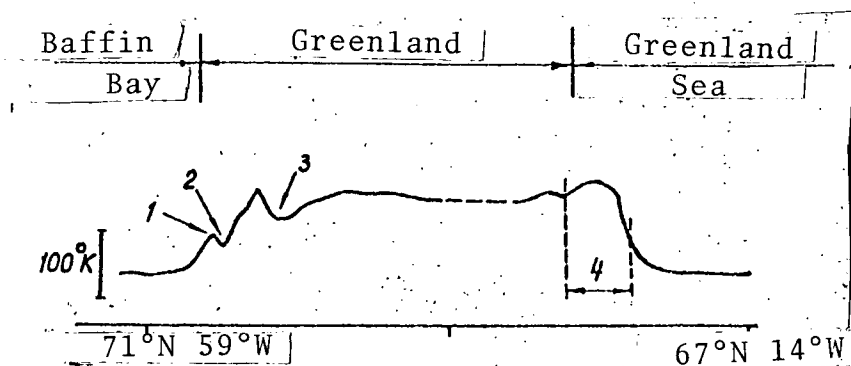


Figure 2. Profile of Radio Brightness Temperature of Greenland, $\lambda = 3.4$ cm; 1, Svartenkhuk Peninsula; 2, Karratsfjord; 3, Region with Low Value of Radio Brightness; 4, Floating Ice

spectral density produced characterizes the distribution of temperature in the surface layer down to these depths. If we note the fact that seasonal fluctuations in temperature do not extend below 3-4 m depth [5], we see that at wavelength λ_1 and to some extent at wavelength λ_2 , the temperature determined is near the mean annual temperature. This is confirmed by results of measurements in comparison with known data from the literature on distribution of temperature through the mass of the Greenland ice [6]. Estimates of the radio brightness of the continent of Greenland at λ_1 and λ_2 give us $T_b = 225-245^\circ\text{K}$. Assuming for the continental ice, according to [3], that $\epsilon = 2.5$, we find that $t = -(15-35)^\circ\text{C}$, while where $\epsilon = 3$, $t = -(10-30)^\circ\text{C}$. The values produced agree with known data on the mean annual temperature in Greenland [6]. The estimates of the spectral dependence of radio brightness on the continental ice of Greenland show little difference between values of temperatures determined for long-wave and short-wave channels. This indicates more even distribu-

tion of temperature through the thickness of the Greenland ice than is the case in Antarctica at the time the measurements were made. More detailed quantitative interpretation of the results of measurement at the shorter wave lengths λ_3 and λ_4 is difficult due to the thick cloud cover present over Greenland and the adjacent regions.

/7

An estimation of the distribution of temperature or dielectric permeability of the floating ice is difficult, due to the strong dependence of properties of floating ice on weather conditions (moisture content of surface, cracks, structural peculiarities). Some estimates of dielectric permeability of floating ice were produced on the basis of values of air temperature and water surface temperature, supplied by the weather service. The great value of radio brightness of the floating ice $T_b = 245-255^\circ K$ indicates that the ice is quite thick, since the water, beneath the layer of floating ice, has no significant influence on formation of radiation and the effective radiating layer is totally within the mass of ice. Using the measurement values of radio brightness of the floating ice and assuming an effective thermodynamic temperature of the radiating layer of about $2^\circ C$, we produce $\epsilon = 2.7-3.6$. This value agrees with known data from direct measurements of dielectric permeability of floating ice.

The recordings of the signal produced flying over Greenland shows sectors with anomalously low radio brightness for ice (snow-firn mass), reaching at the minimum $T_b = 160-180^\circ K$ (Figure 2, Sector "3"). Comparison of these sectors with the map of Greenland (Figure 1) shows broad area "1," up to 1000 km long and 150-200 km wide, extending from $71^\circ N$ to the southern tip of the continent along $45^\circ W$ (western slope of the ice shield of Greenland). This peculiarity can be explained by the moistening of the surface due to thawing or precipitation in the form of rain or wet snow. The photographs of this region produced by the ESSA-6 and 7 weather satellites indicate a complex weather situation, accompanied by thick frontal cloud cover. Estimates of the

/8

effective dielectric permeability of the surface in this region show that $\epsilon = 20-25$.

Analysis of the data produced shows that radiometric measurements by satellite allow us to determine:

- the ice situation in the high latitudes;
- the thermodynamic temperatures, near the mean annual temperatures, and estimates of the vertical distribution of thermodynamic temperature;
- peculiarities of the weather situation resulting in wetting of the cover.

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